CLAIMS

1. A display device for generating a three-dimensional volumetric image, comprising:

a two-dimensional image display panel (41, 46) for generating a two-dimensional image;

a first focusing element (42, 47) for projecting the two-dimensional image to a virtual image (40, 45) in an imaging volume (44, 49); and

means (53, 120, 150) for altering the effective optical path length between the display panel and the projecting first focusing element so as to alter the position of the virtual image within the imaging volume, wherein the means for altering the effective optical path length includes an optical path length adjuster for varying an effective optical path length between an input optical path (52) and an output optical path (54), comprising:

a first polarisation switch (160) for selecting a polarisation state for an input beam on the input optical path (52); and

an optical element (141, 161, 201) having birefringent properties and thereby defining at least two possible effective optical paths of different lengths therethrough, for passing the input beam along a selected one of said at least two possible optical paths according to the selected polarisation state of the input beam and for providing an output beam of light, on said optical output path (54), that has travelled along the selected optical path.

2. The apparatus of claim 1 in which the birefringent optical element (161) has its optic axis orthogonal to the optical axis defined by the input path (52) and the output path (54).

3. The apparatus of claim 1 further including an optical element (165), 201) for at least partially correcting for astigmatism.

4. The apparatus of claim 3 in which the birefringent optical element (165) includes a cylindrically-shaped optical surface for correcting for astigmatism.

5. The apparatus of claim 4 in which the birefringent optical element (165) further includes a fitting, non-birefringent counterpart element (166) attached to the cylindrically-shaped optical surface.

6. The apparatus of claim 5 in which the counterpart element (166) has a refractive index substantially equal to the ordinary index of refraction of the birefringent element (165).

7. The apparatus of claim 3 in which the birefringent optical element comprises a spherical lens (201).

8. The apparatus of claim 7 in which the spherical lens is a plano-convex lens (201).

9. The apparatus of claim 1 further including an optical element for at least partially correcting for spherical aberration.

10. The apparatus of claim 9 in which the birefringent optical element is a cylindrically corrected plane-parallel plate and in which the spherical aberration correction element is a spherical lens.

11. The apparatus of claim 9 in which the birefringent optical element is a spherical lens and in which the spherical aberration correction element is a plane-parallel plate.

12. The apparatus (53, 150) of any preceding claim combined with at least one further optical path length adjuster (53, 150) of any preceding claim in a cascade formation, such that the output optical path (54) of the first said

optical path length adjuster (150) forms the input path (52) of a successive said further optical path length adjuster (53, 150).

13. The apparatus of claim 12 in which the optical paths of each said optical path length adjuster (53, 150) include different optical path lengths such that a plurality of possible overall optical path lengths are selectable by appropriate selection of path length within each said optical path length adjuster.

14. The apparatus of claim 13 in which each successive optical path length adjuster in the cascade has a thickness of birefringent optical element which is different from any other birefringent optical element in the cascade.

15. The apparatus of any preceding claim including a further optical path length adjuster, the further optical path length adjuster comprising:

a first polarisation switch (60) for selecting a polarisation state for an input beam on an input optical path (52); and

first and second beam splitters (61, 62, 105, 106) having at least two possible optical paths (63, 64, 110, 111, 112) of different lengths therebetween, for passing the input beam along a selected one of said at least two possible optical paths according to the selected polarisation state of the input beam and for providing an output beam of light, on an optical output path (54), that has travelled along the selected optical path.

16. The apparatus of claim 15 in which the first beam splitter (105) has a first optical input (105a) coupled to the optical output of the first polarisation switch (101), for diverting light at the optical input of the first splitter to first and second optical outputs (105b, 105c) respectively according to a polarisation state of the light at the optical input of the first splitter;

the second beam splitter (106) has first and second optical inputs (106a, 106b) respectively optically coupled to the first and second outputs (105b, 105c) of the first beam splitter (105), via respective said first and

second optical paths (110, 111), the second beam splitter (106) diverting light at the first and second inputs (106a, 106b) to first and second outputs (106c, 106d) of the second beam splitter (106) according to a polarisation state of light at the first and second inputs thereof;

the first output (106c) of the second beam splitter (106) defines the optical output path (54), and the second output (106d) of the second beam splitter is optically coupled to a second input (105d) of the first beam splitter (105) via a third optical path (112);

each of the first, second and third optical paths (110, 111, 112) respectively includes one of a second, a third and a fourth polarisation switch (104, 102, 103),

the first, second, third and fourth polarisation switches adapted to thereby select cumulative combinations of one or more of said first, second, and third optical paths between the input optical path (52) and the output optical path (54).

17. The display device of claim 3 in which the display panel (51) is positioned at a distance from the birefringent optical element (141, 161, 201) such that astigmatic aberration is substantially minimised or eliminated.

18. The display device of claim 3 in which the display panel (51) is positioned at a distance from the birefringent optical element (141, 161, 201) such that spherical aberration is substantially minimised or eliminated.

19. The display device of claim 9 in which the display panel (51), the birefringent optical element (141, 161, 201) and the spherical aberration correction element (203, 205) are relatively positioned such that spherical aberration is substantially minimised or eliminated.

20. A method for generating a three-dimensional volumetric image, comprising the steps of:

generating a two-dimensional image on a two-dimensional image display panel (41, 46);

projecting the two-dimensional image to a virtual image (40, 45) in an imaging volume (44, 49) with a first focusing element (42, 47); and

altering the optical path length between the display panel and the projecting focusing element so as to vary the position of the virtual image within the imaging volume by varying an effective optical path length between an input optical path (52) and an output optical path (54) of an optical path length adjuster (53, 150, 120) positioned between the display panel and the projecting focusing element, comprising the steps of:

selecting a polarisation state for an input beam of light on the input optical path using a first polarisation switch (160);

passing the input beam into an optical element having birefringent properties and thereby defining at least two possible effective optical paths of different lengths therethrough, the input beam travelling along a selected one of said at least two possible effective optical paths according to the selected polarisation state of the input beam; and

providing an output beam of light, from the birefringent optical element on said optical output path (54).

21. The method of claim 20 further including the step of at least partially correcting for astigmatism.

22. The method of claim 20 further including the step of at least partially correcting for spherical aberration.

23. The method of claim 20 further including the step of passing the beam through at least one further optical path length adjuster such that the output optical path (54) of the first said optical path length adjuster (150) forms the input path (52) of a successive said further optical path length adjuster (53, 150), and selecting optical path length using each optical path length adjuster.

24. The method of claim 20 further including the step of positioning the optical path length adjuster at a distance from an object to be imaged so as to minimise astigmatic aberration.

25. The method of claim 20 further including the step of positioning the optical path length adjuster relative to an object to be imaged so as to minimise spherical aberration.

26. The method of claim 23 further including the step of selecting different optical path lengths within each said optical path length adjuster (53a, 53b).